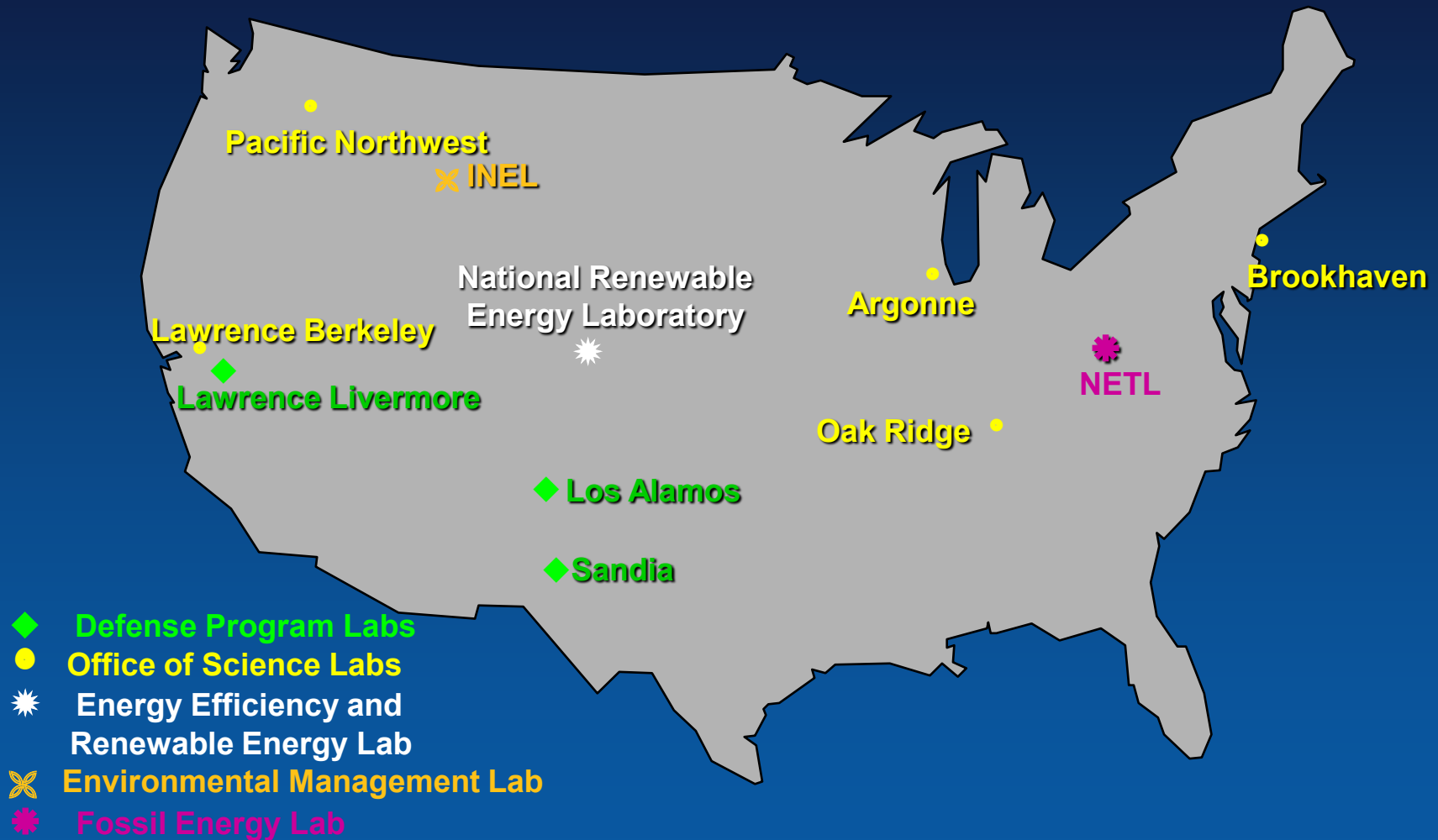


Energy in a Changing World

Roger Taylor

National Renewable Energy Laboratory

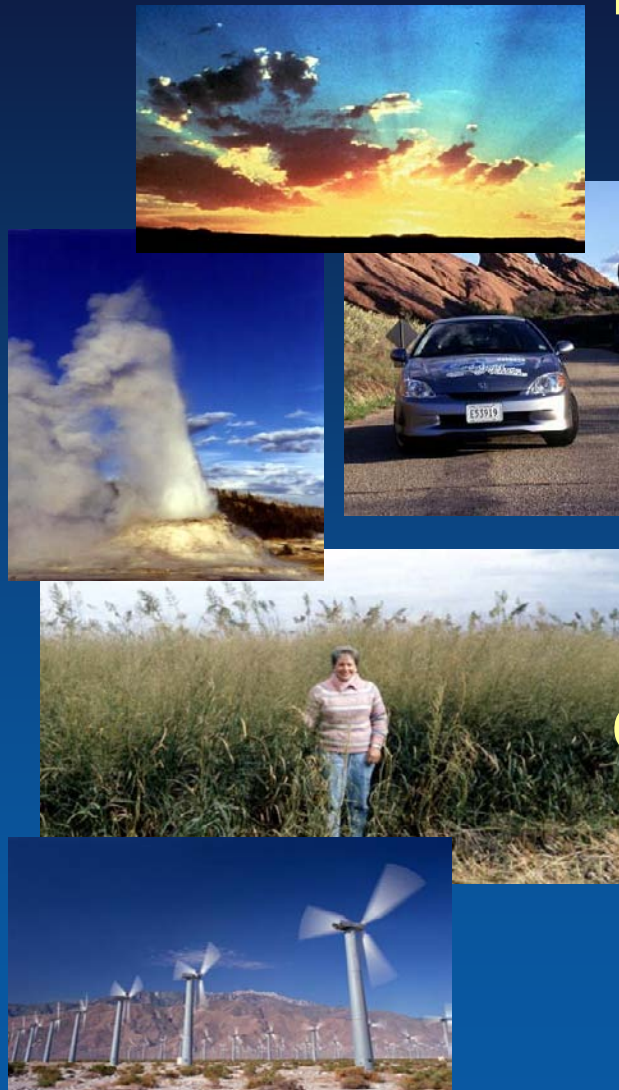
Major DOE National Laboratories



Major NREL Technology Thrusts

Supply Side

Wind Energy
Solar Photovoltaics
Concentrating Solar
Power
Solar Buildings
Biomass Power
Biofuels
Geothermal Energy
Hydrogen
Superconductivity
Distributed Power

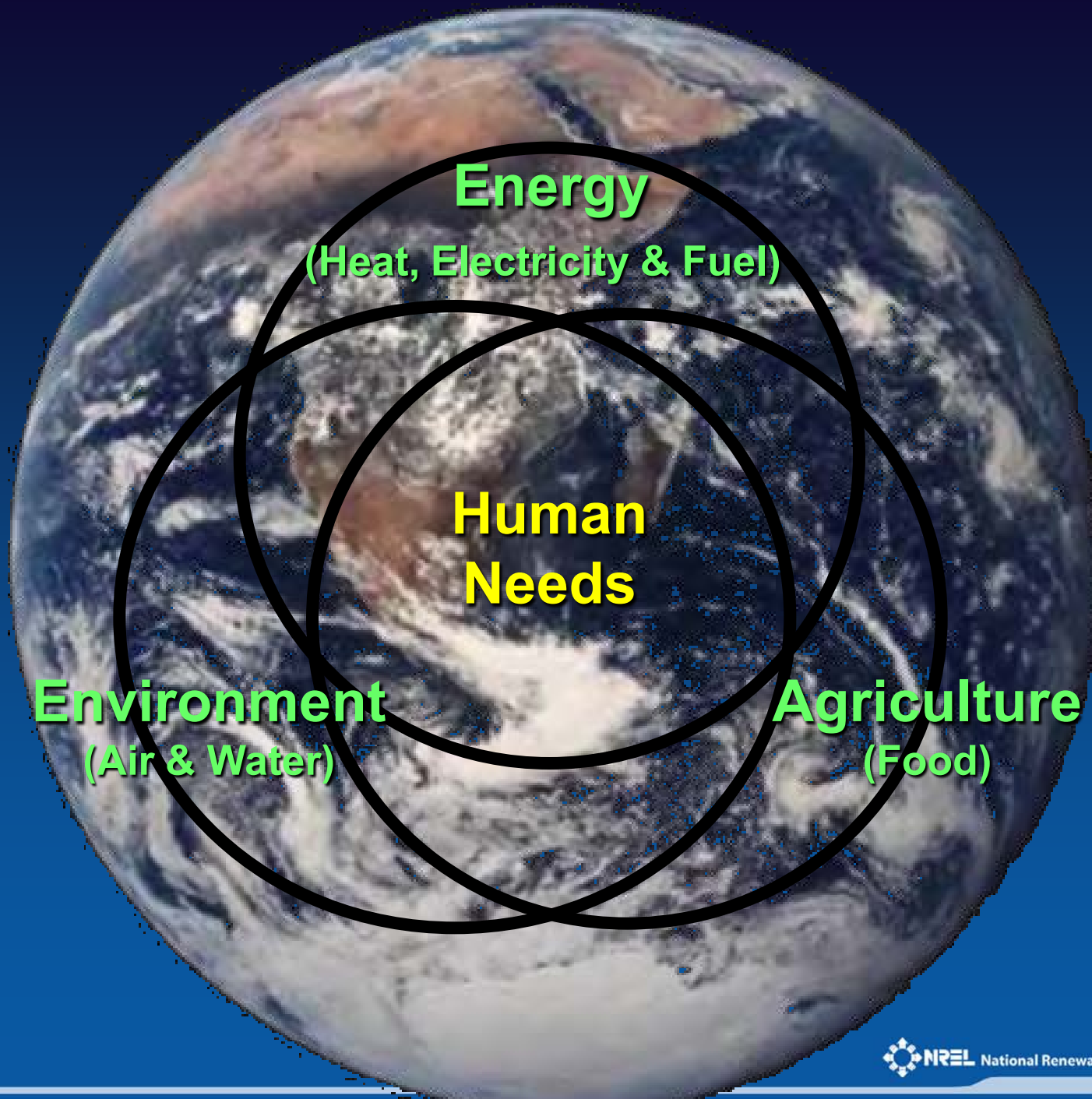


Demand Side

Hybrid Vehicles
Fuels Utilization
Buildings Energy
Technology
Federal Energy
Management
Advanced Industrial
Technologies

Cross Cutting

Basic Energy Science
Analytical Studies
International Programs
Tribal Energy Program



Energy

(Heat, Electricity & Fuel)

**Human
Needs**

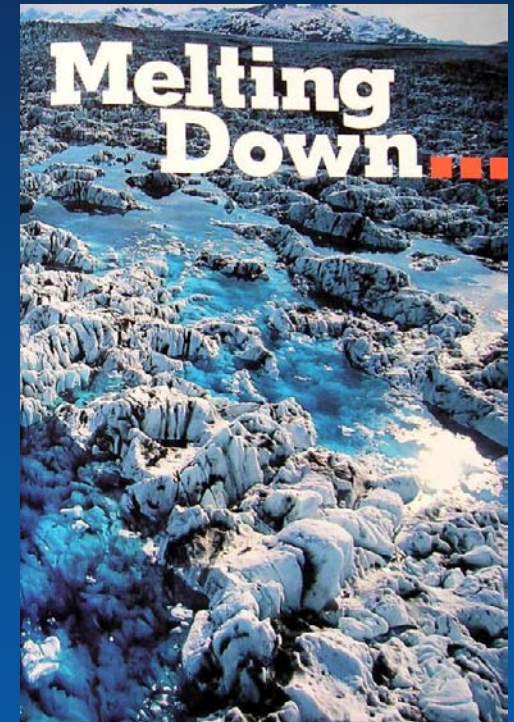
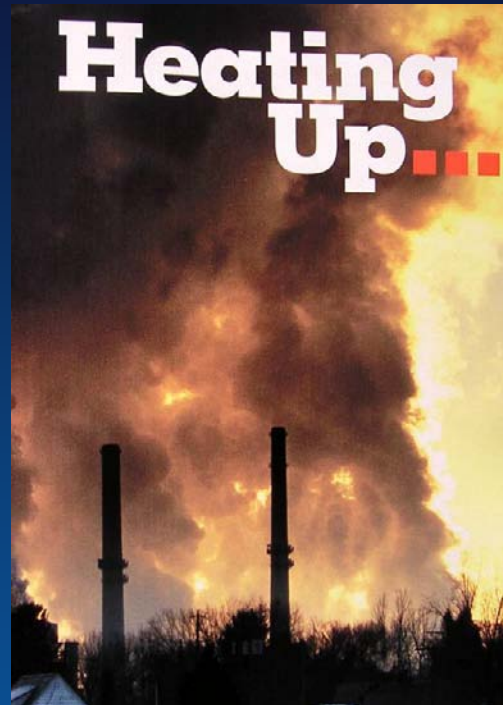
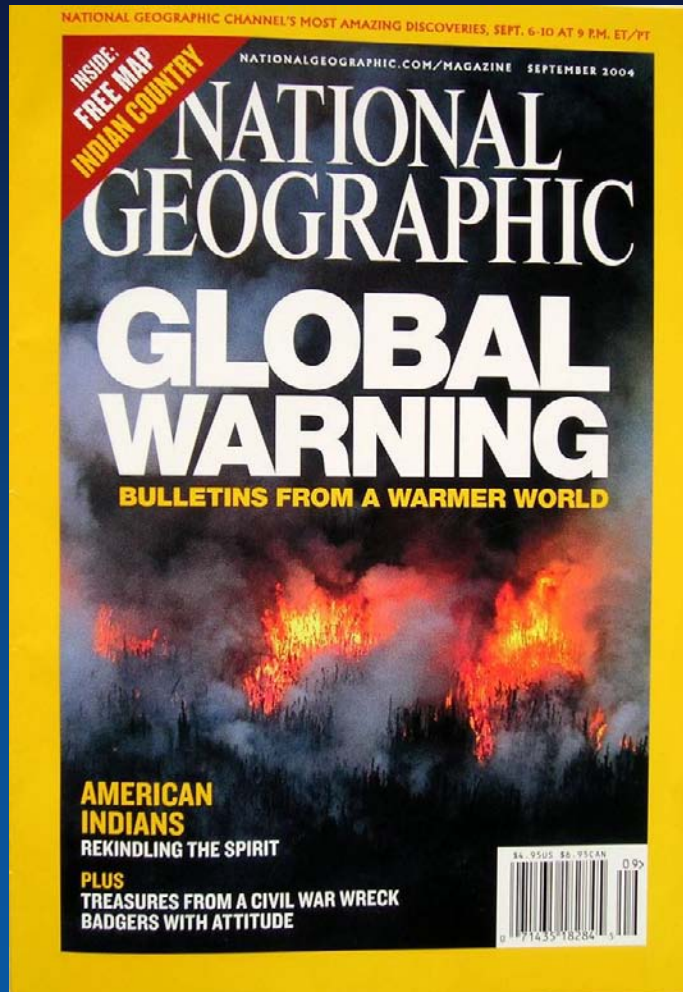
Environment

(Air & Water)

Agriculture

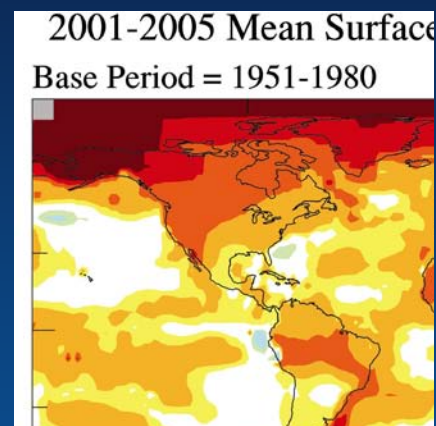
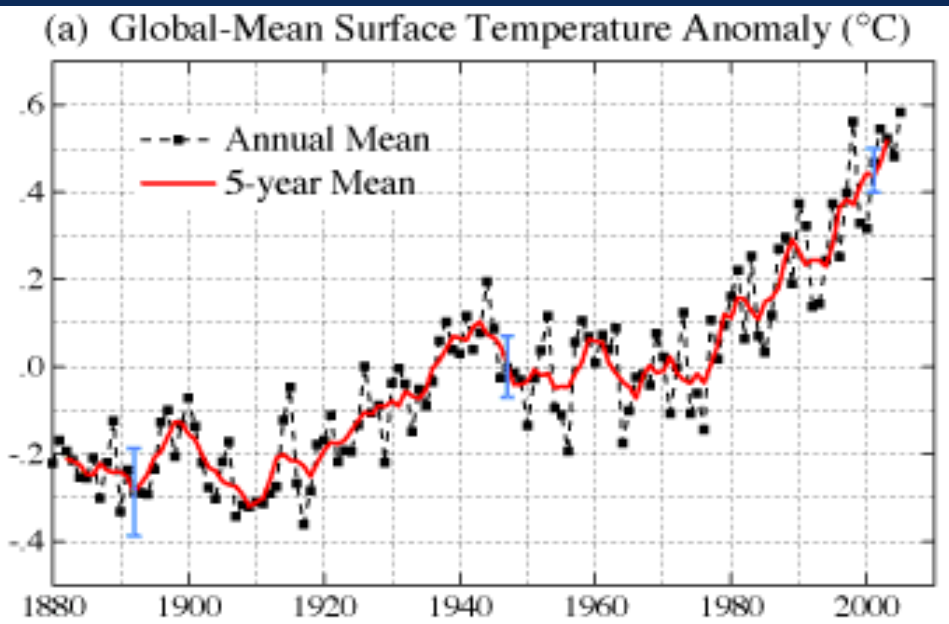
(Food)

We Live in a Changing World



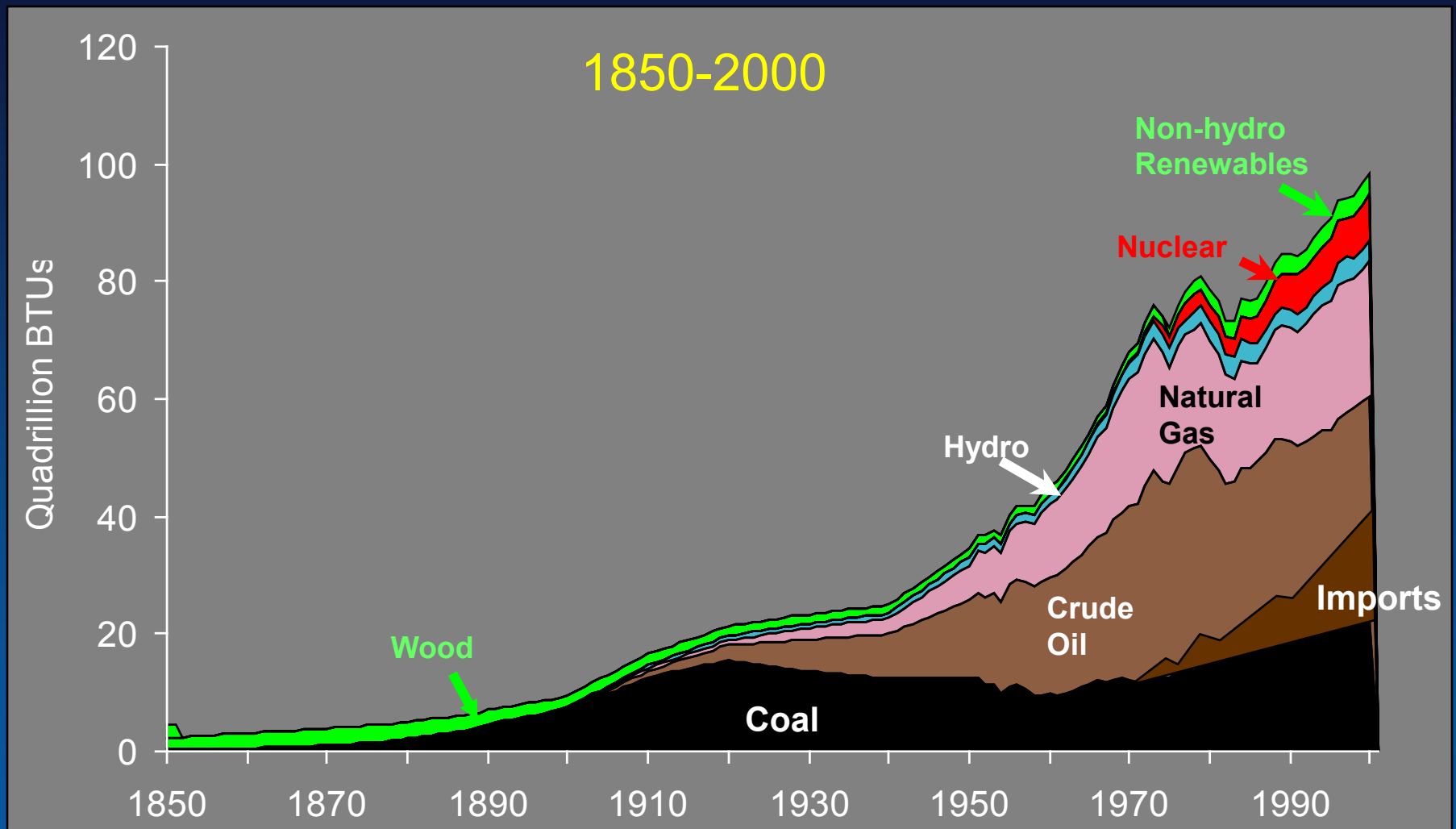
Where Carbon Reduction is a Requirement

2005 Warmest Year on Record



Warming of $0.2^{\circ}\text{C}/\text{decade}$ over last 30 years

Where U.S. Energy Consumption Continues to Grow



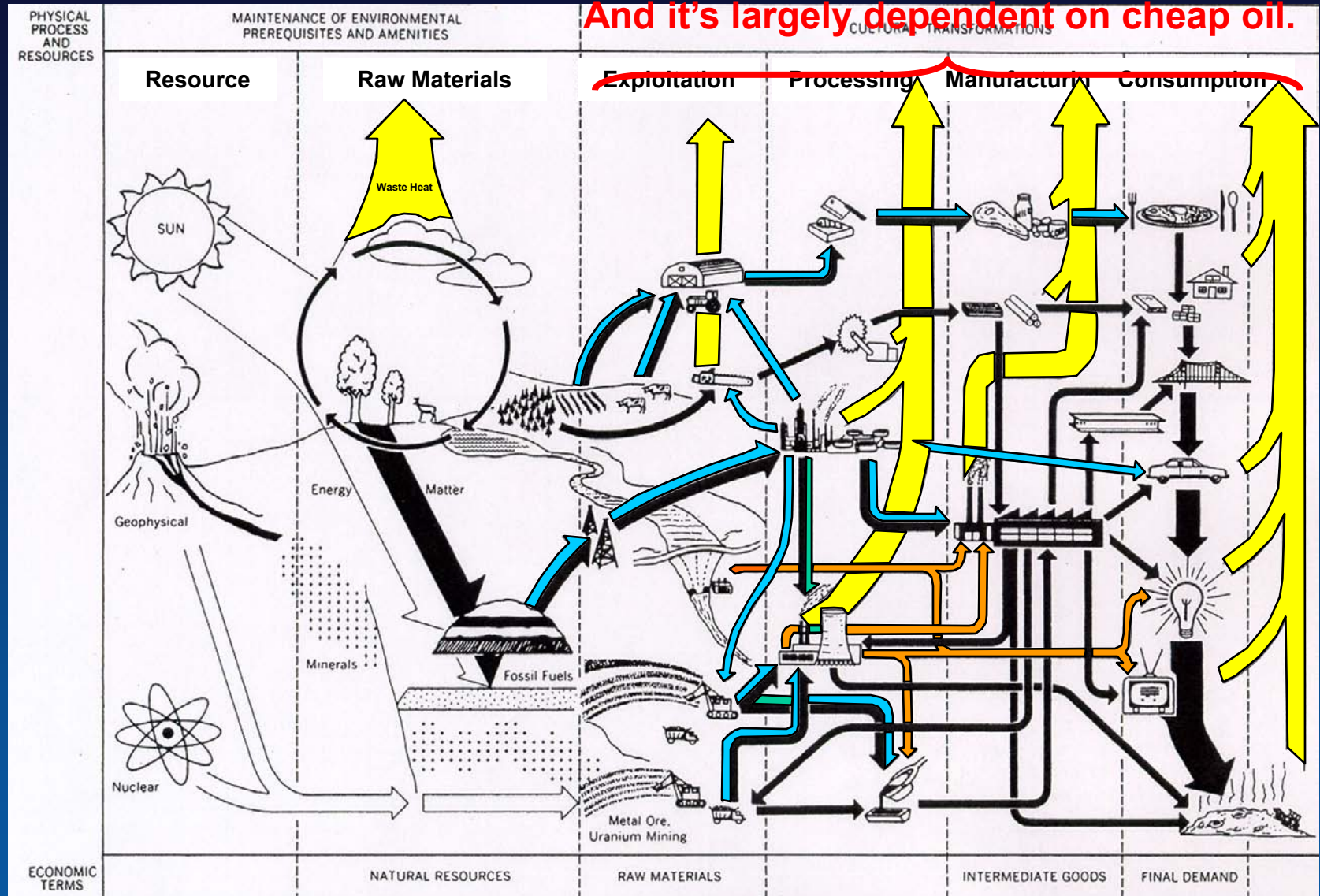
Source: 1850-1949, Energy Perspectives: A Presentation of Major Energy and Energy-Related Data, U.S. Department of the Interior, 1975; 1950-2000, Annual Energy Review 2000, Table 1.3.



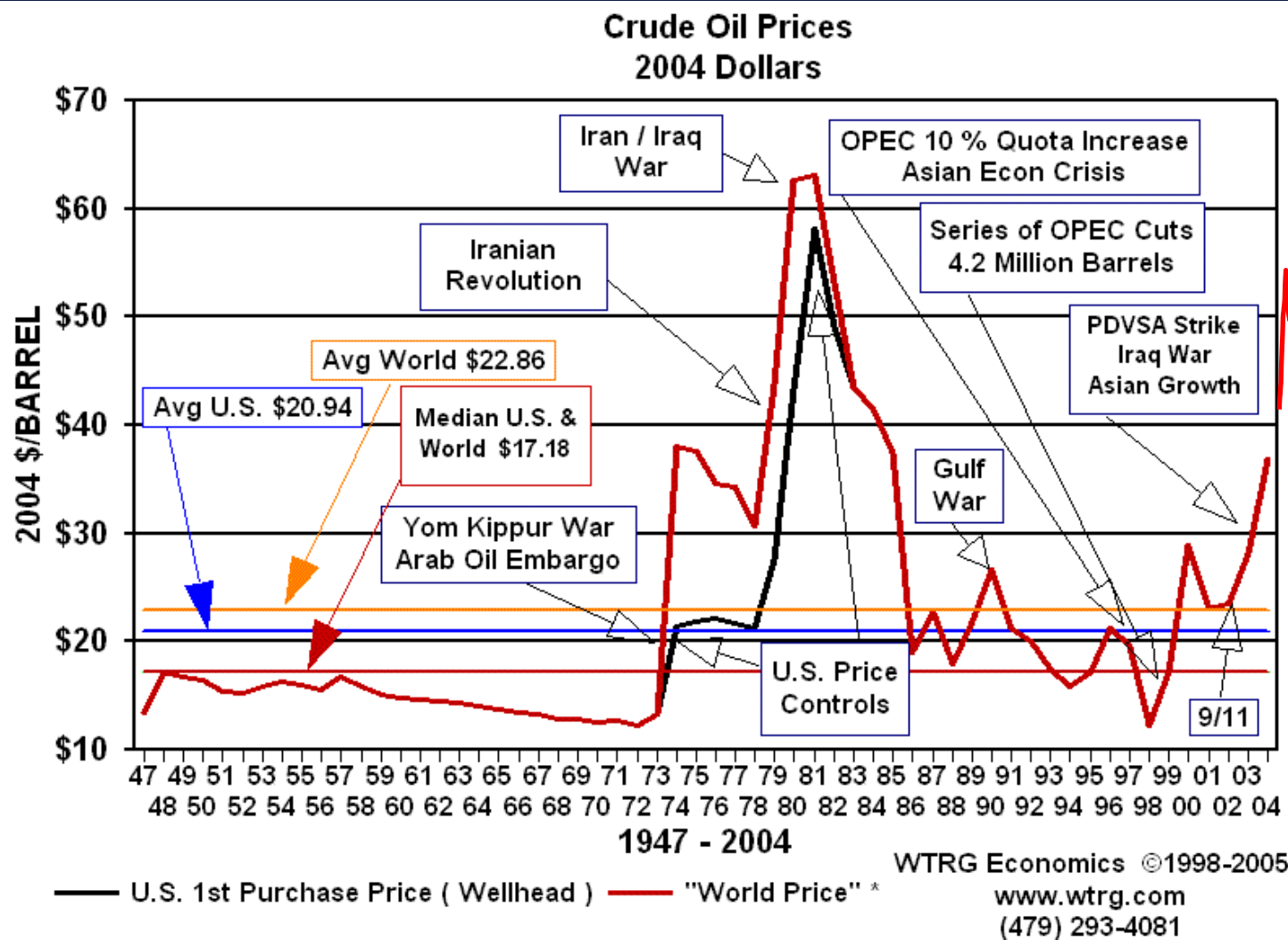
National Renewable Energy Laboratory

Where the global economy is very complex

And it's largely dependent on cheap oil.



Increasingly volatile, increasingly upward



~\$95/bbl

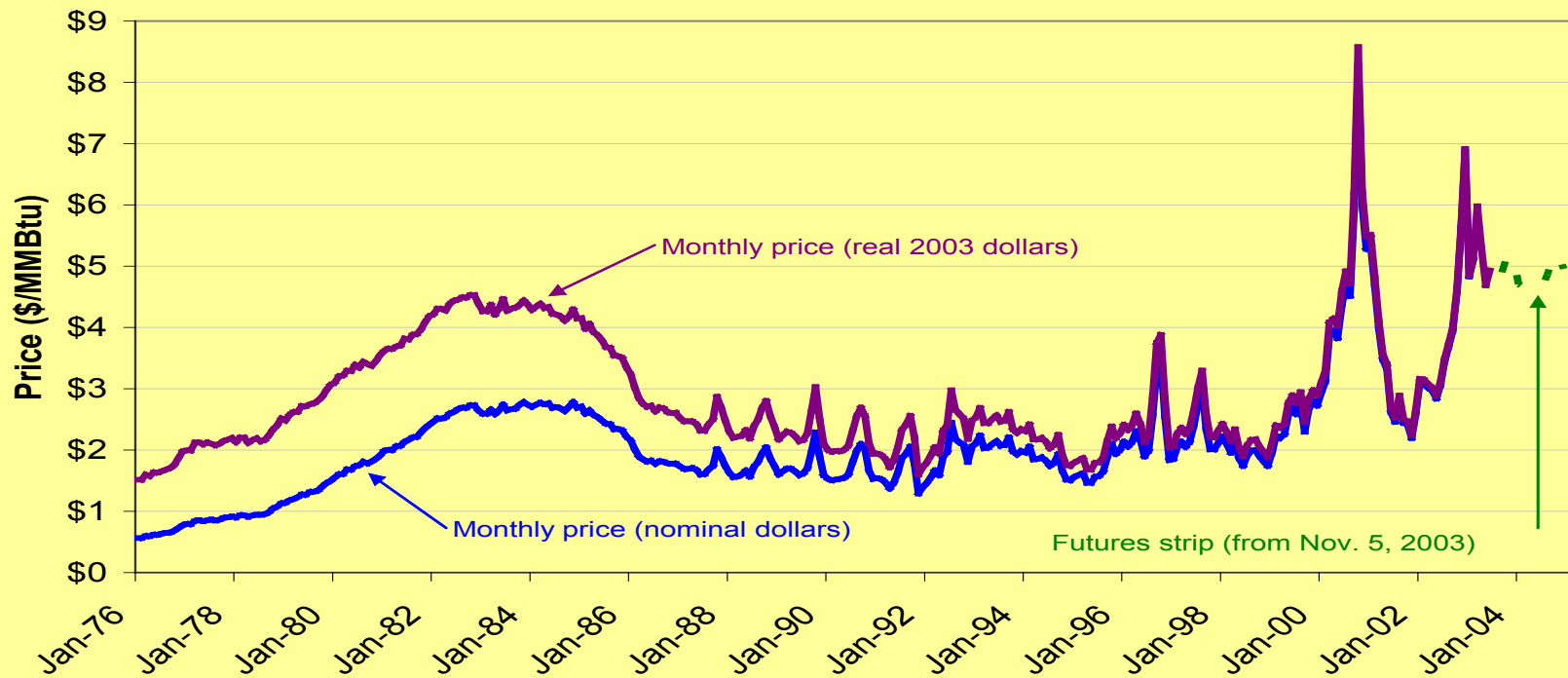
~\$77/bbl

~\$60/bbl

After a decade of low prices, natural gas prices are now more volatile at a higher level.

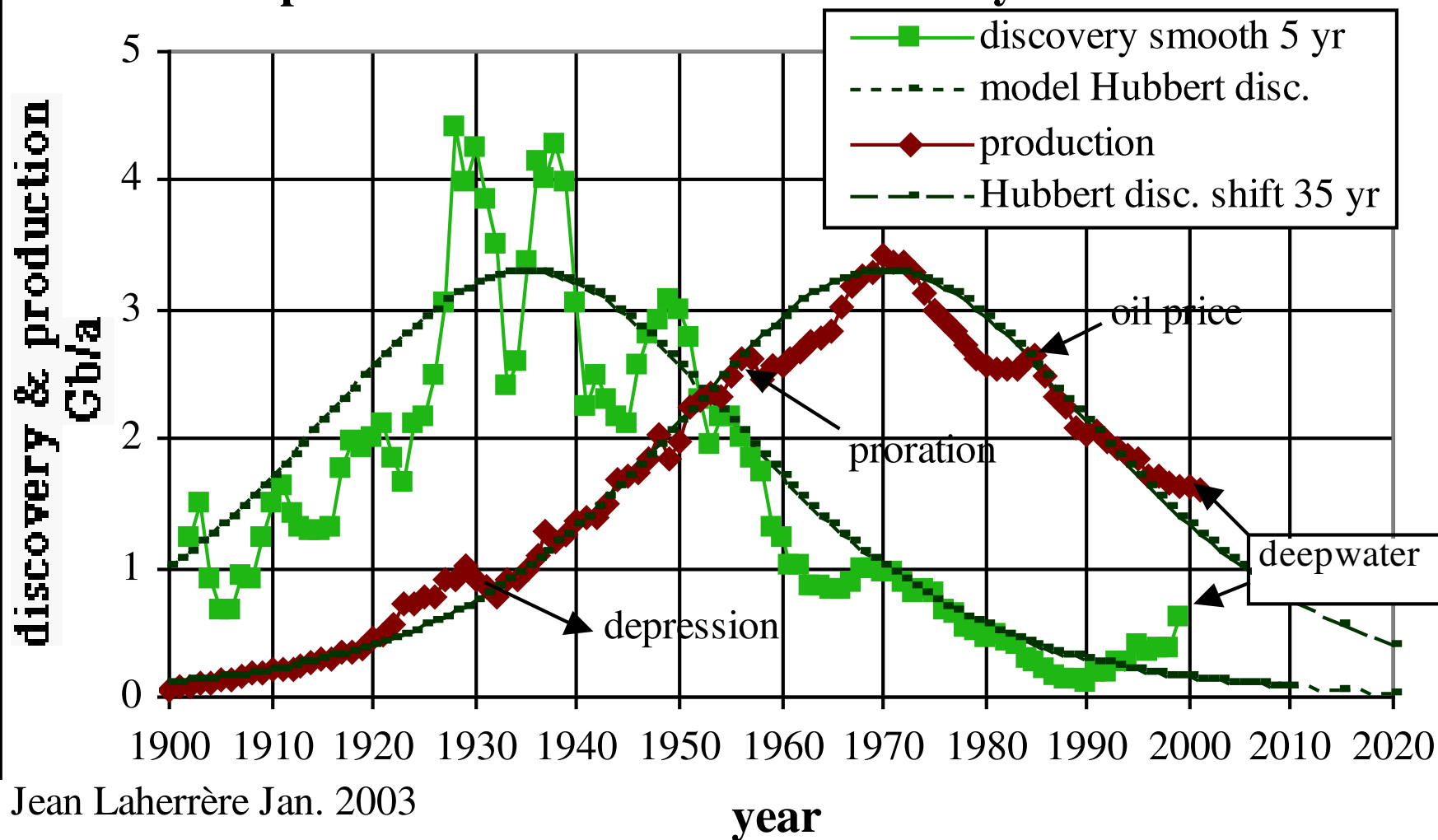
~\$15
MMBTU
Henry
Hub

~\$8.00
MMBTU



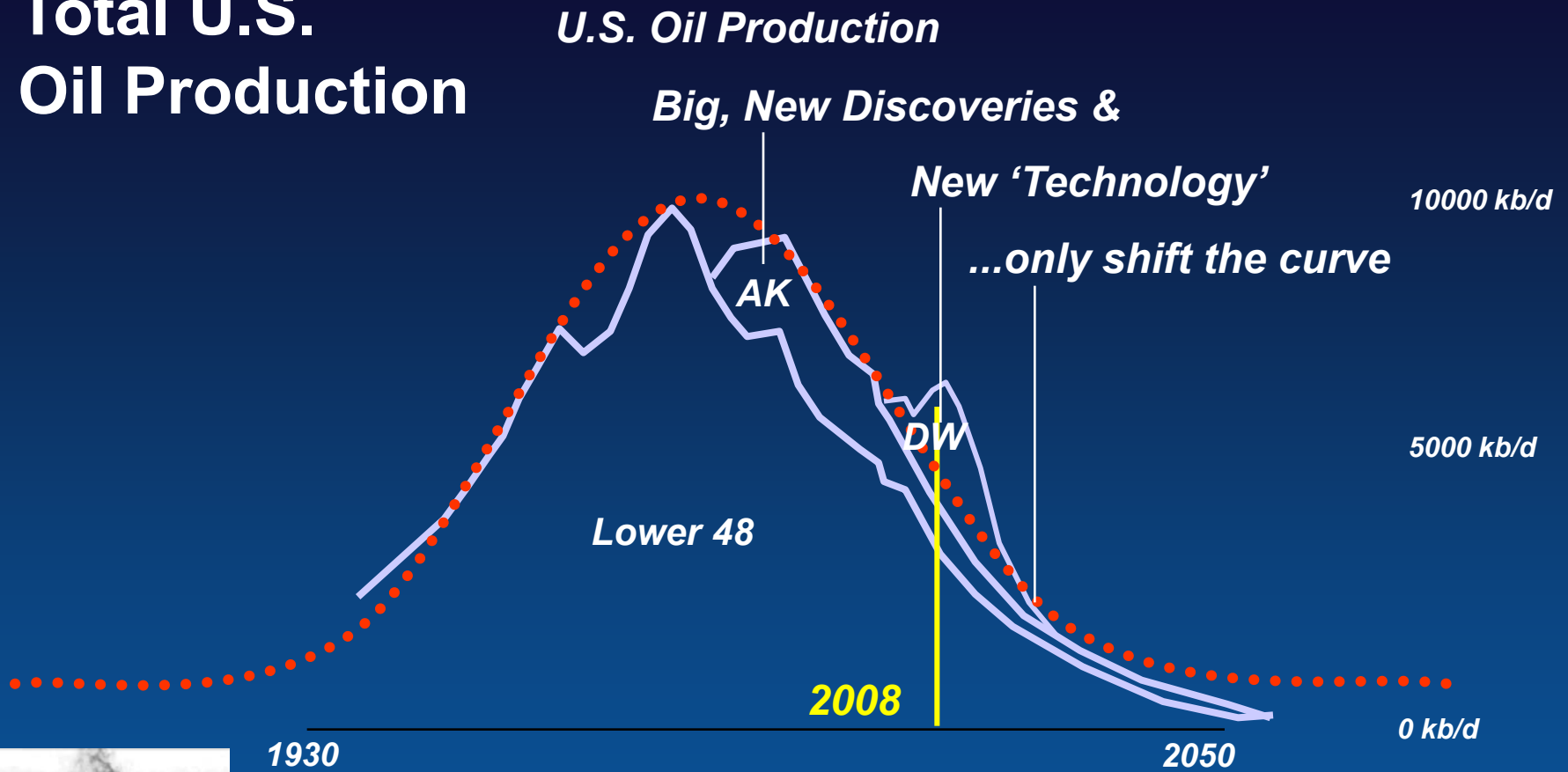
US Lower 48 Oil Discovery & Production

US Lower 48: annual oil "mean" discovery & production with Hubbert discovery model



Jean Laherrère Jan. 2003

Total U.S. Oil Production



Lower 48

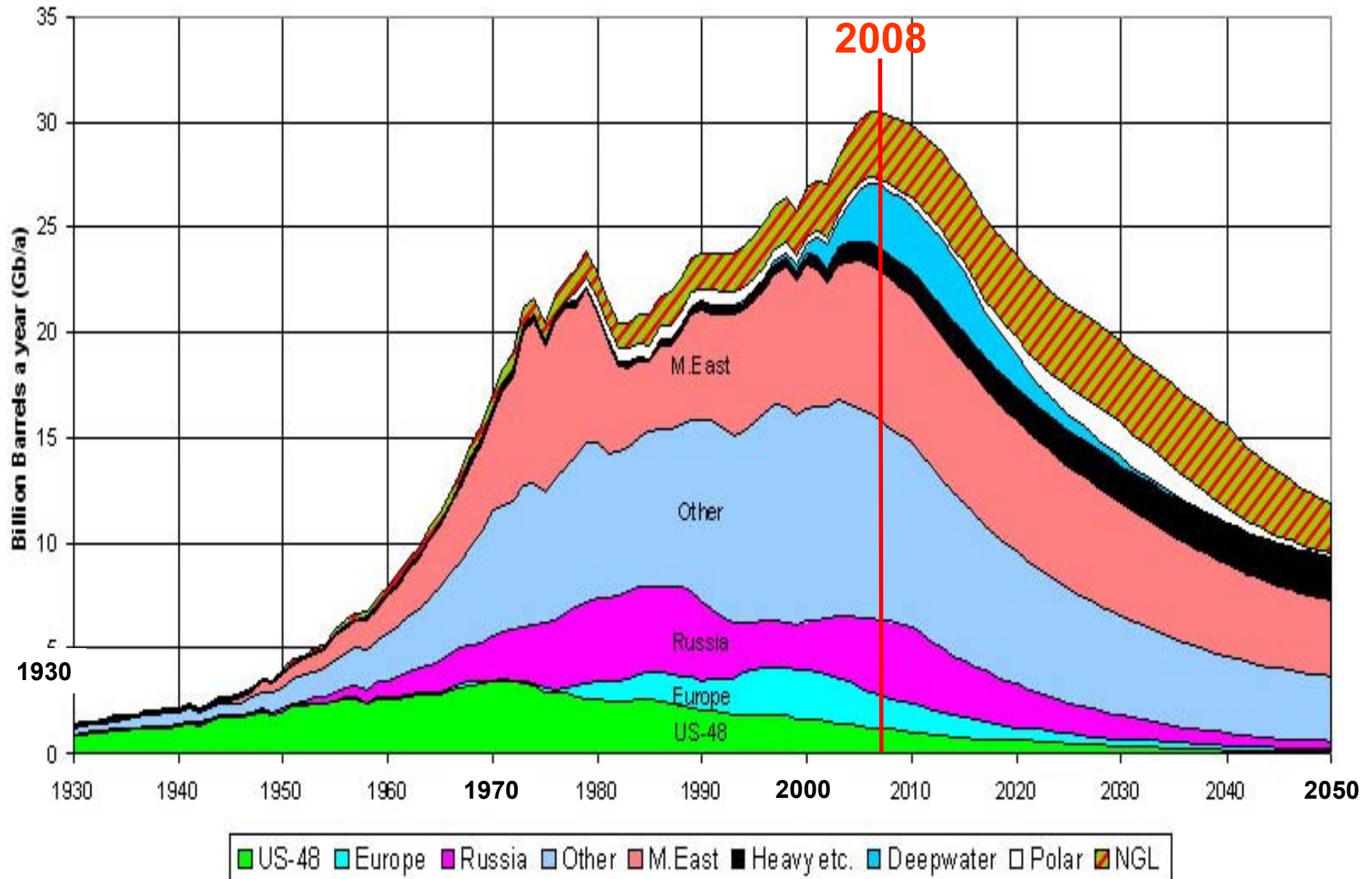


Alaska



Deepwater

The Age of Oil



7 Generations Span The Age of Oil

Our Great Grand Parents

Our Grand Parents

Our Parents

Our Generation

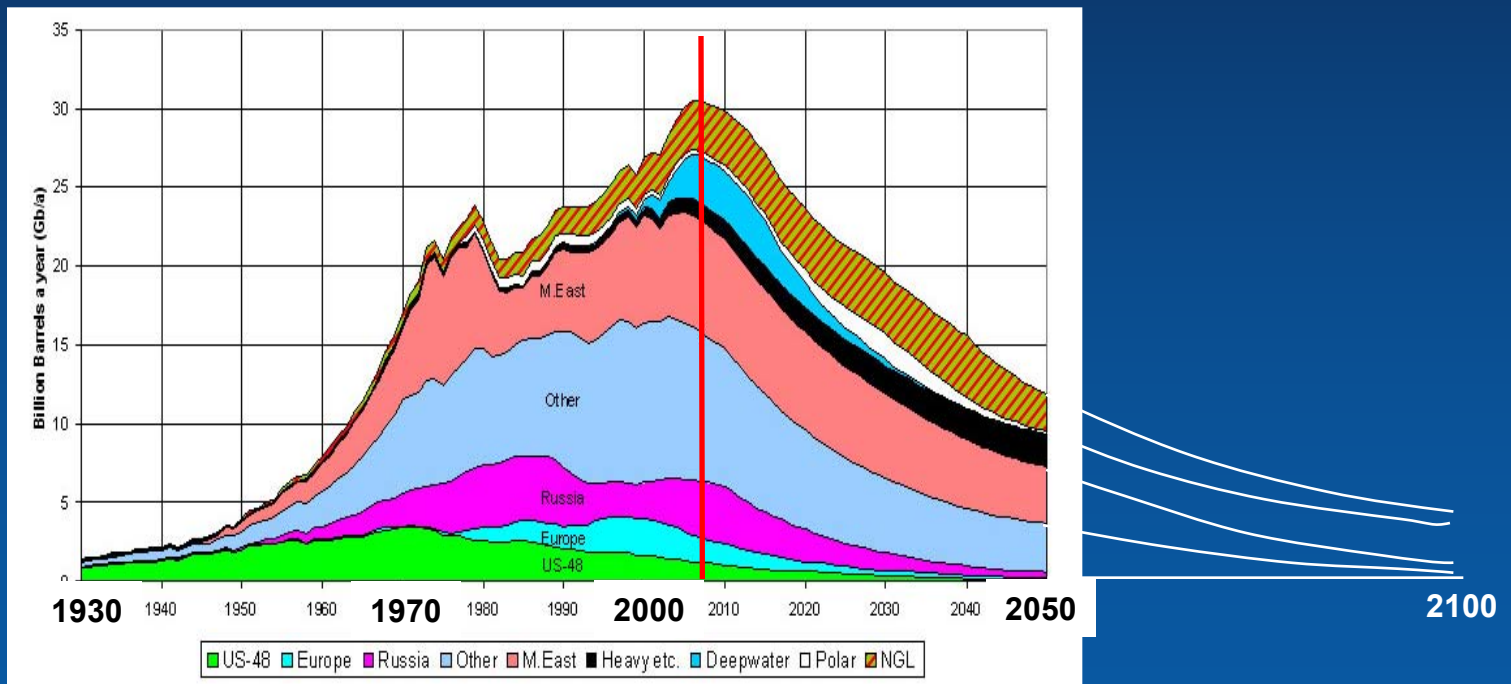
80

20

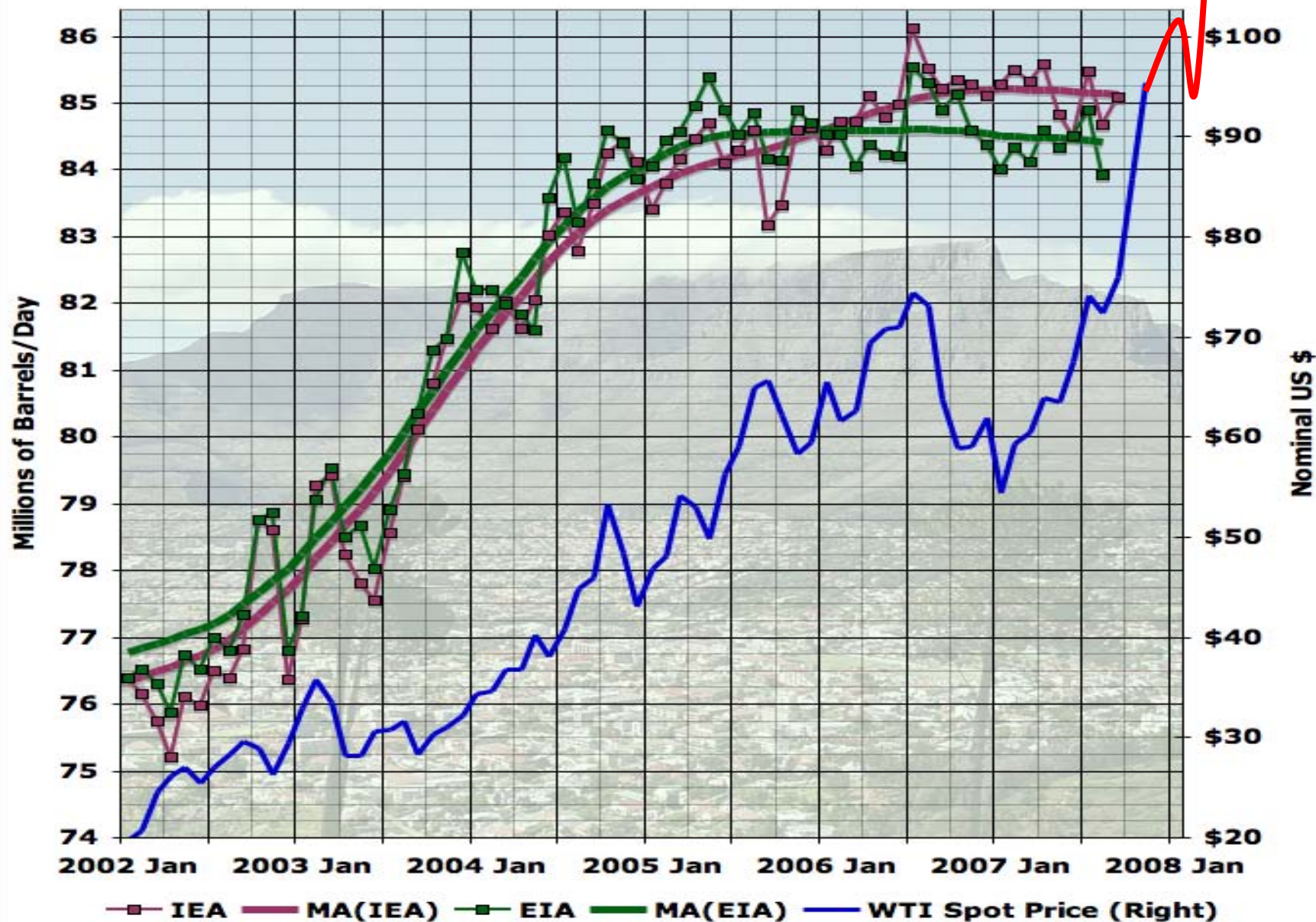
Our Children

Our Grand Children

Our Great Grand Children

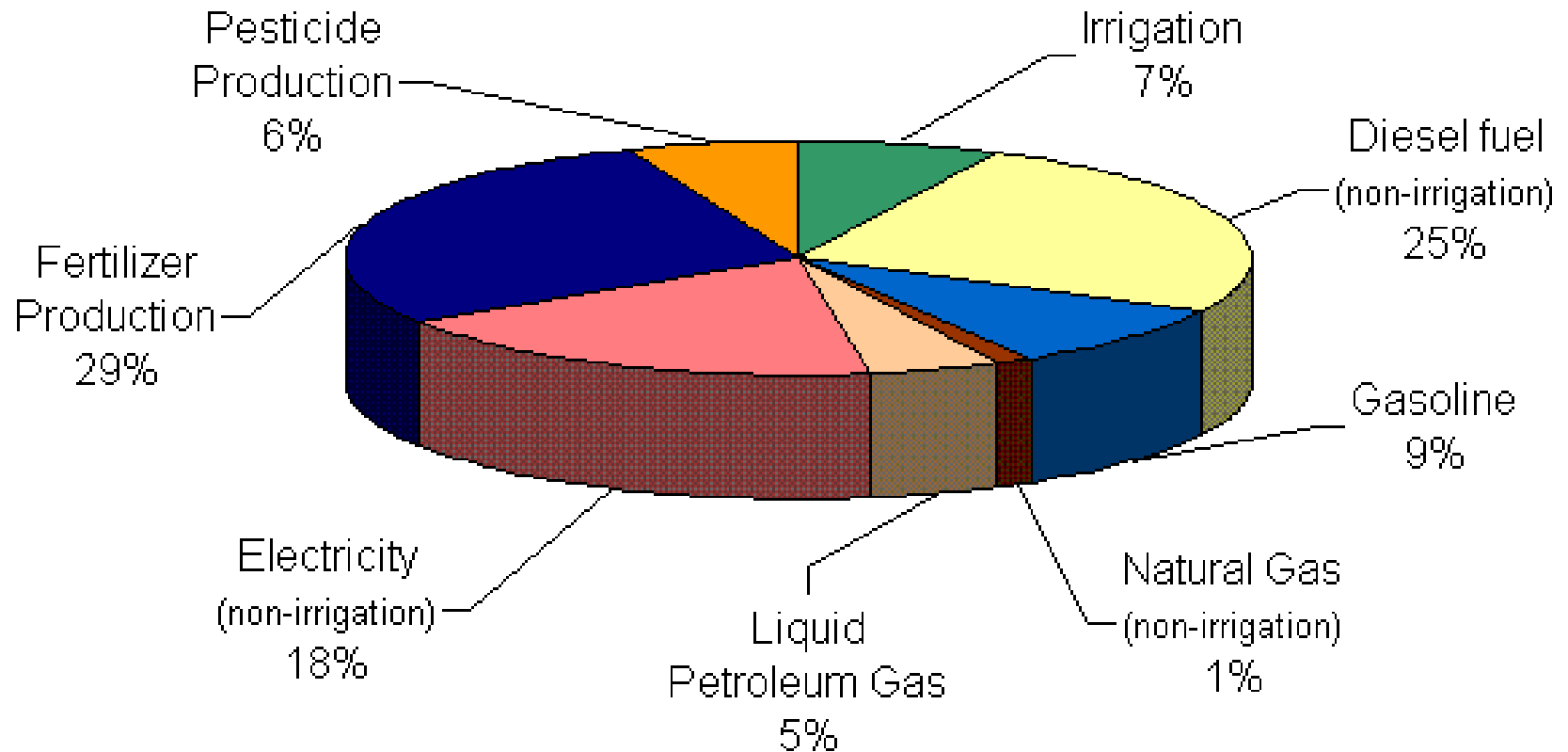


\$113



U.S. Farm Energy Use, 2002

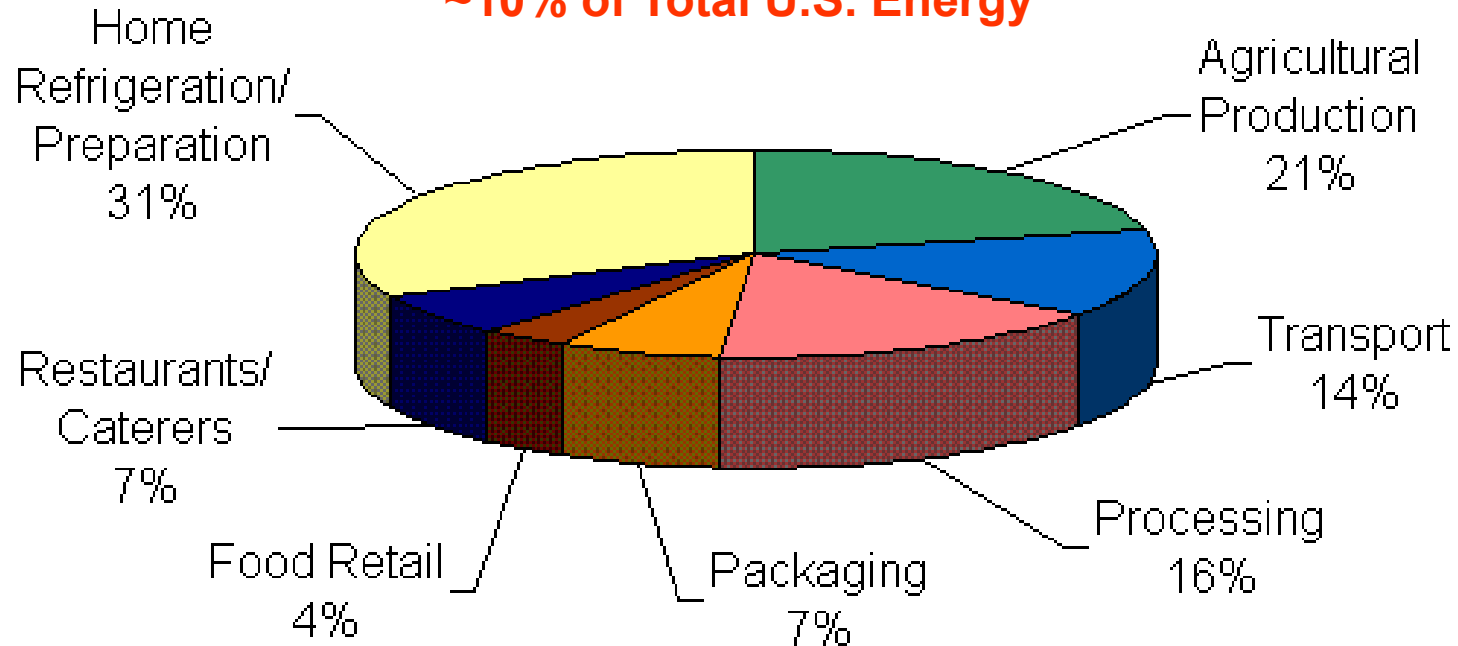
~75% Petroleum (assuming electric Irrigation)



United States Food System Energy Use

Total = 10.25 Quadrillion Btu

~10% of Total U.S. Energy



Source: Heller and Keoleian

Pineapples to Des Moines



By sea from Costa Rica
0.3 gallons

By air from Hawaii
2.8 gallons

Three Great Challenges of the 21st Century

Energy, Climate, Food

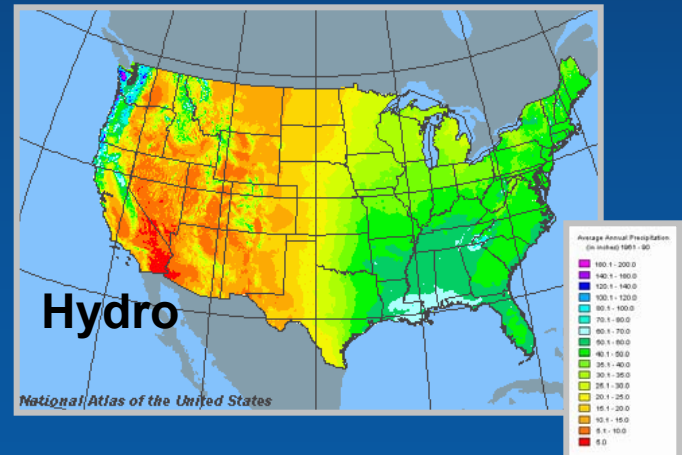
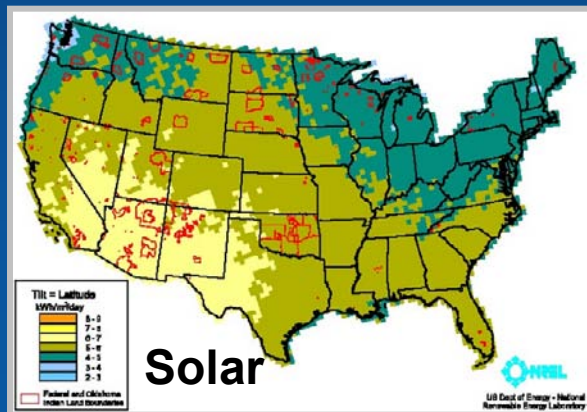
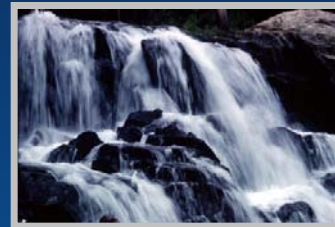
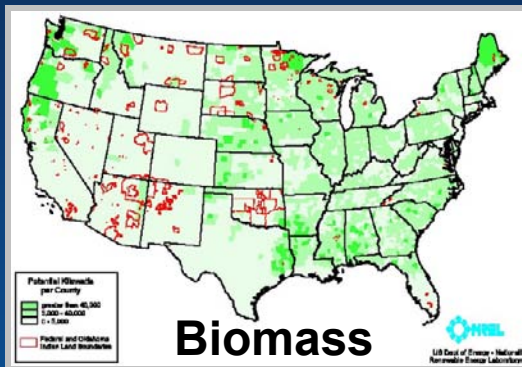
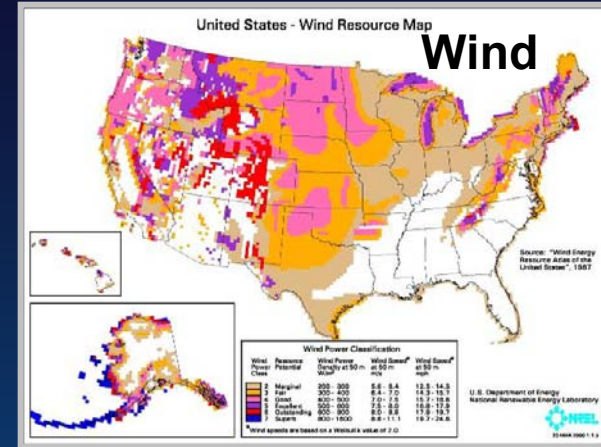
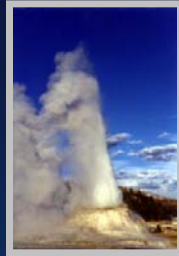
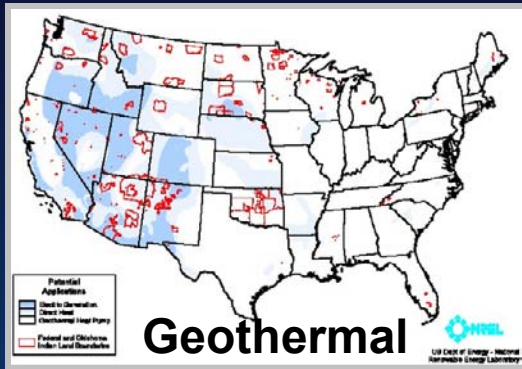
The Perfect Storm

It's time to
change direction

SS Global Economy

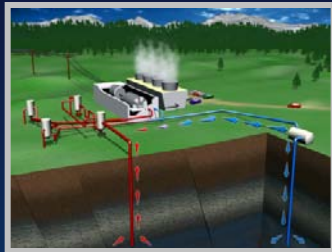


Renewable Resource Options



Renewable Technology Options

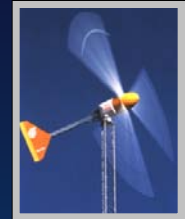
Power



Small Modular Power



Small Wind



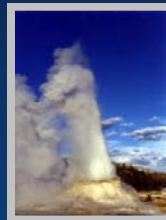
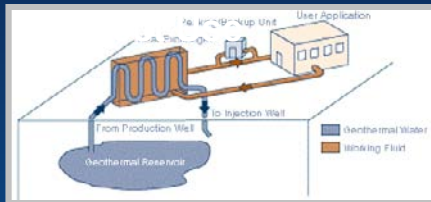
Diesel Hybrids



Big Wind



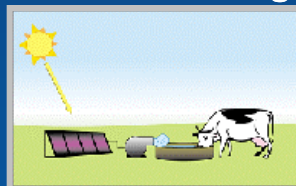
Direct Use



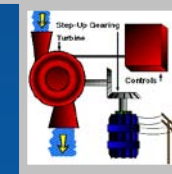
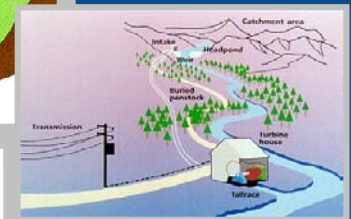
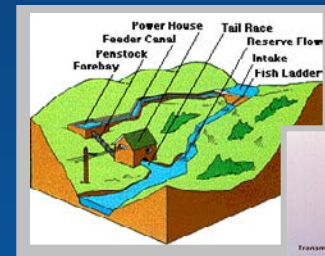
PV - Remote Homes



Stock Watering



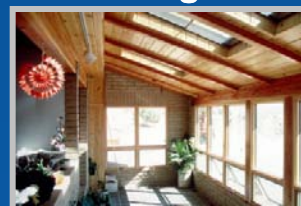
Small Hydro



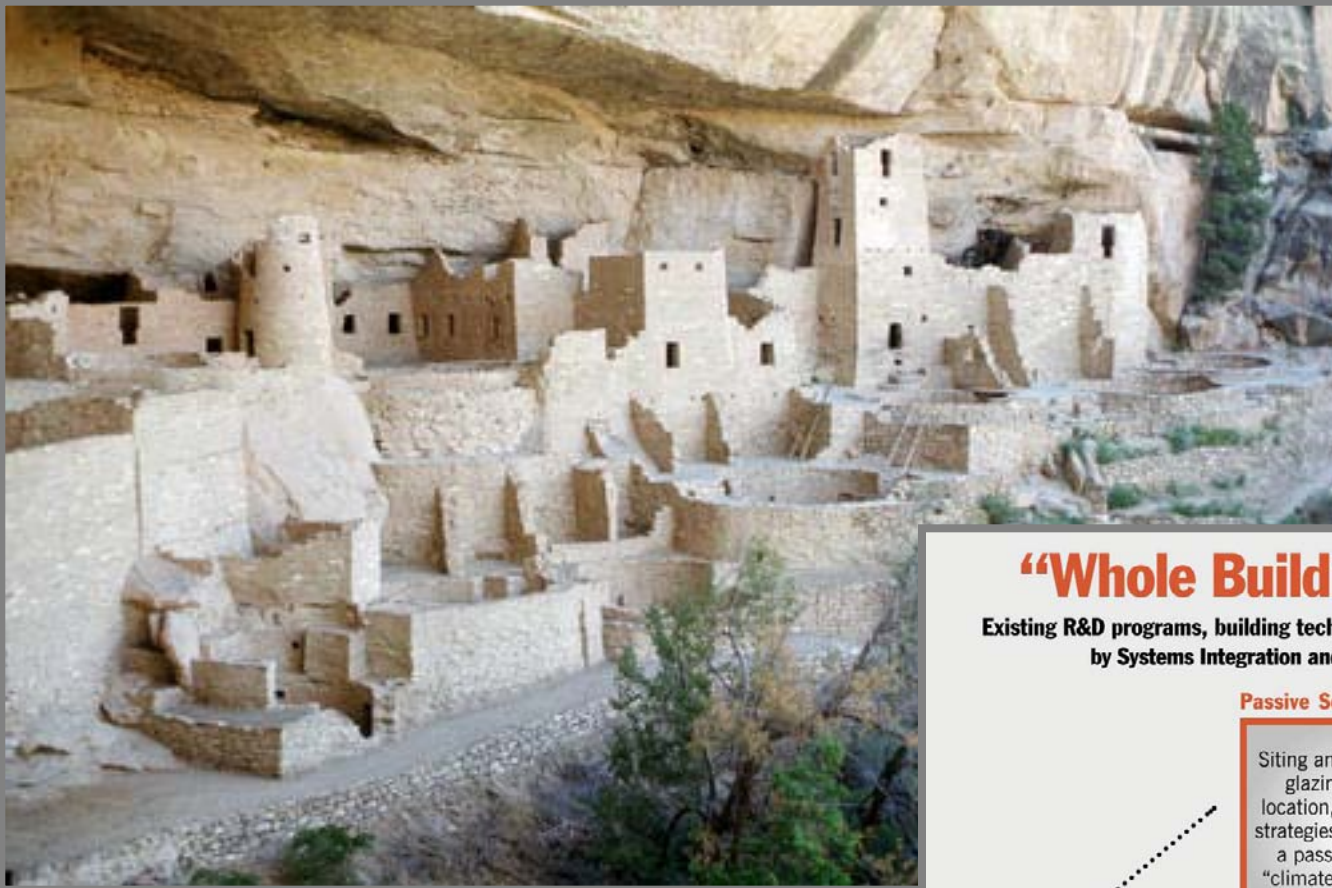
Process Heat



Buildings

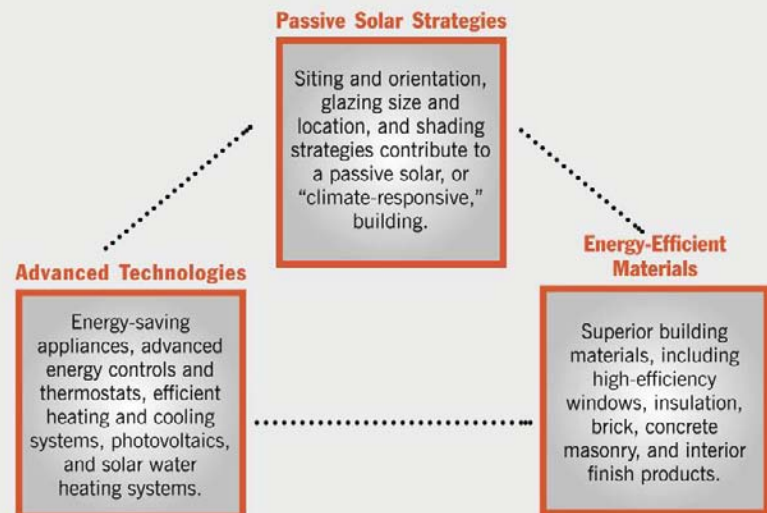


Building Design



“Whole Buildings” Strategy:

Existing R&D programs, building technologies, and components tied together by Systems Integration and Computerized Design Tools.



Energy Efficiency



Energy Star Appliances

Refrigerators – Half as much energy



Clothes Washers – Save up to \$110 per year



Oil & Gas Boilers – Save up to 10%



Programmable Thermostats – Save up to \$100 per year



Efficient Lighting



If every American changed out 5 lights, we'd save \$6 billion/year and the equivalent of 21 power plants.



Wind Turbine Sizes and Applications



Small (≤ 10 kW)

Homes

Farms

Remote Applications
(e.g. water
pumping, telecom
sites, icemaking)



Intermediate (10-250 kW)

Village Power

Hybrid Systems

Distributed Power

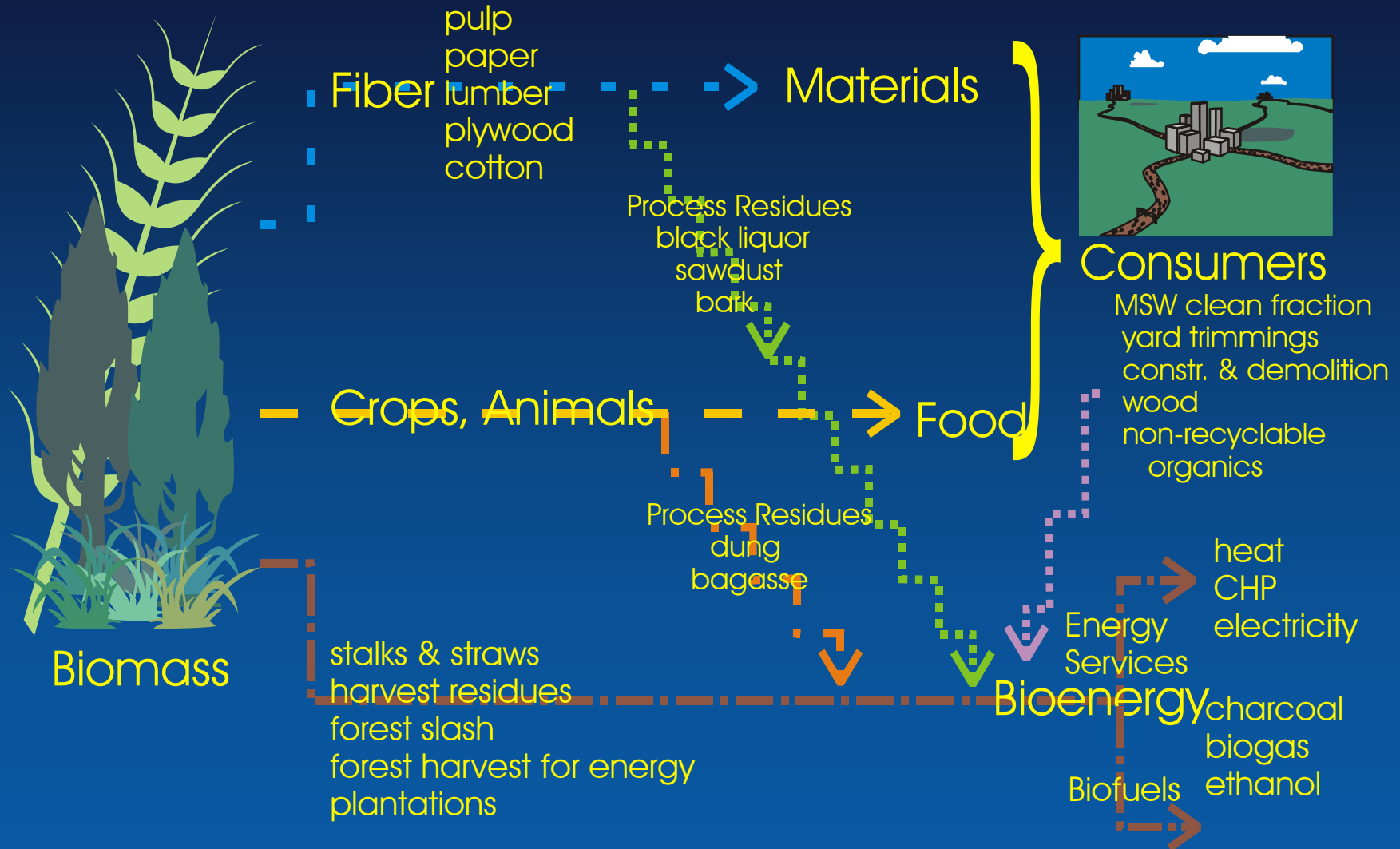


Large (250 kW – 2+ MW)

Central Station Wind Farms

Distributed Power

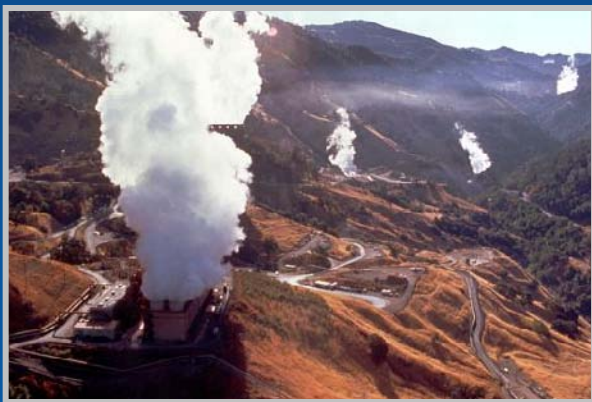
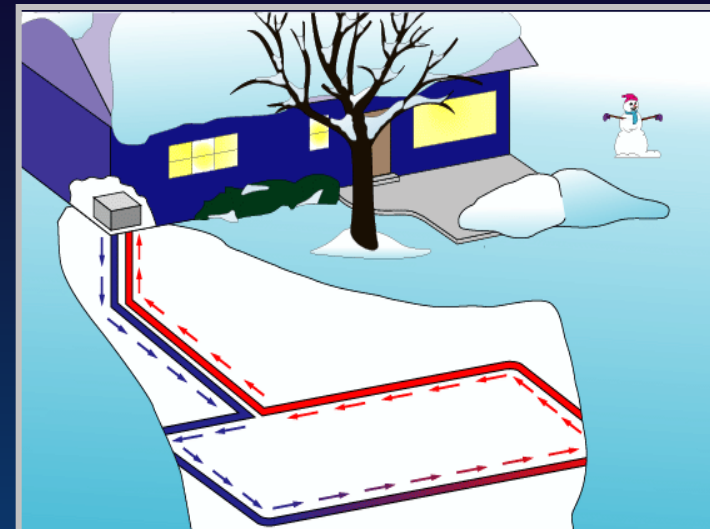
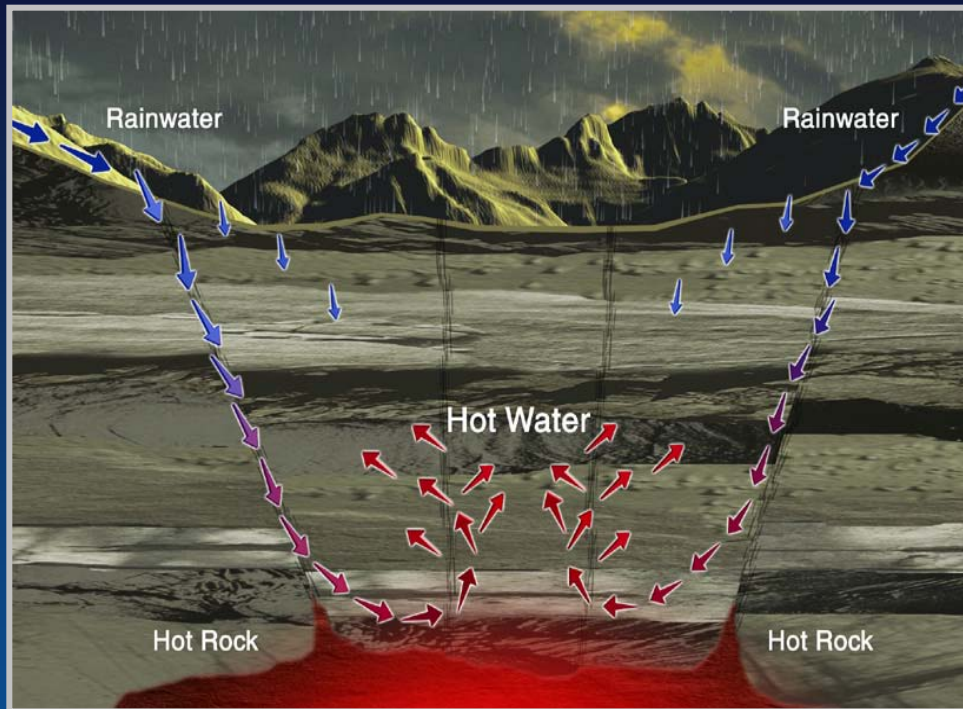
Biomass & Bioenergy Flows



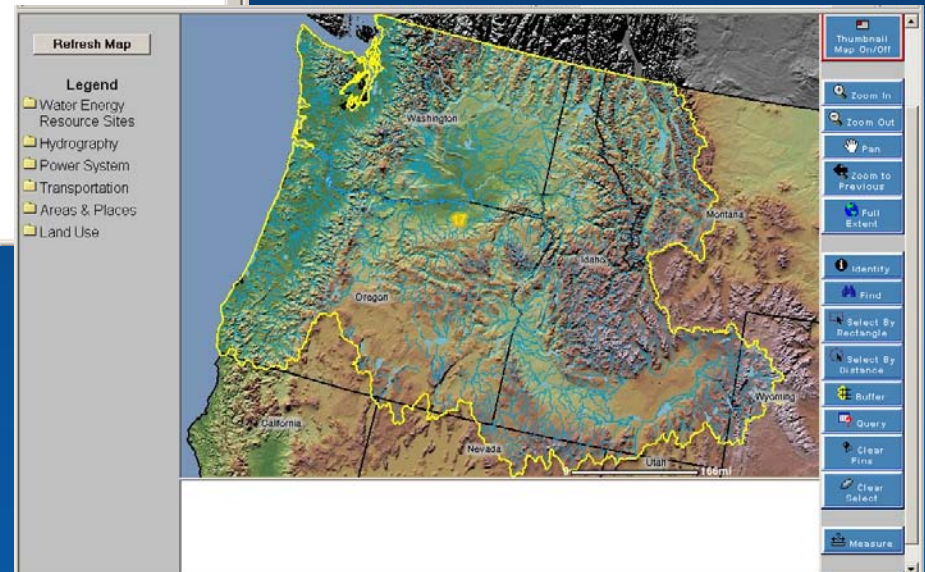
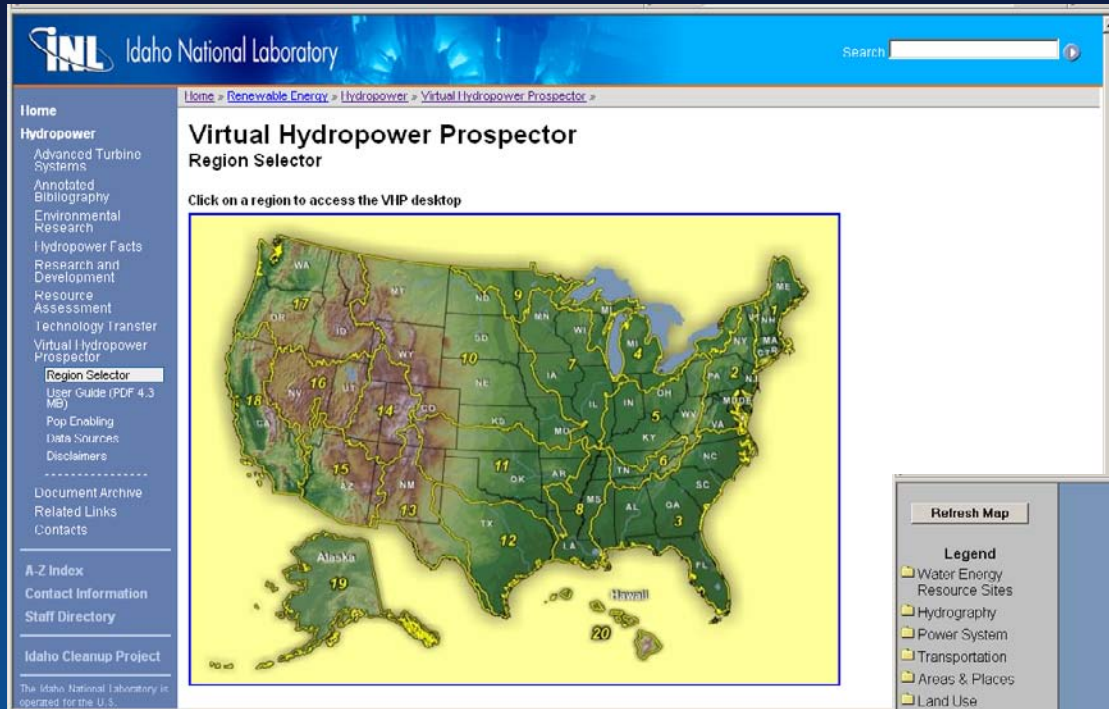
Solar Options



Geothermal Options

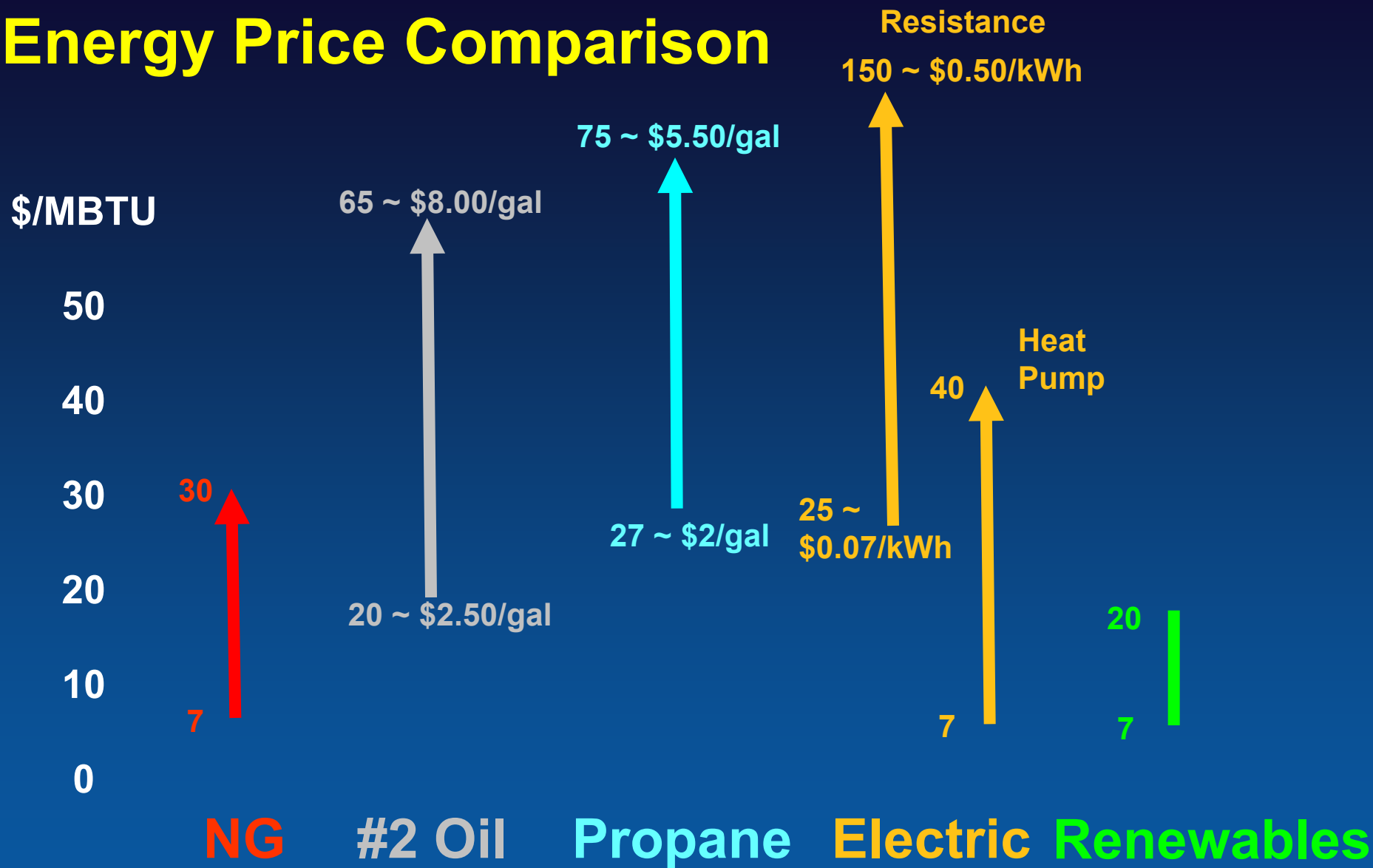


Small Hydro Power



<http://hydropower.inl.gov/prospector/>

Energy Price Comparison



Some Challenging Questions:

- Where have we come from, and where are we going?
- What can we learn from the past?
- How do we shift from individualism to partnerships?
- How do we improve communication and coordination?
- How do we shift from modernism (new, bigger, faster) to community?
- How do we reduce consumption and produce locally?
- Civilizations are built on surplus. How do we shift from surplus to enough?
- A goal of communities is to provide and protect.
 - How do we move to more local production?
 - How do we shorten the supply chains?
 - How do we move from fuel to food?
- How do we develop our local sources of energy?
 - Heat, power, liquid fuels at a community scale, vs. commercial scale
 - What are our local opportunities for energy efficiency and renewables?
- How do we plan for contraction and avoid collapse?

Tribal Energy Security & Sovereignty Through Local Self-Sufficiency

Economic Dependence

Oil Imports
Fuel at the Pump
National Grid
Coal-based Power
Water Transport
Foreign Manufacturing
Agro-Industry

“He who has the gold,
makes the rules.”



Community Independence

Self sufficiency
Food
Energy
Water

Skill Rebuilding
Local Production
Regional Sourcing

Sufficiency & Enoughness
Human Satisfaction

“Community of Cooperation”

The Community Energy Development Challenge

